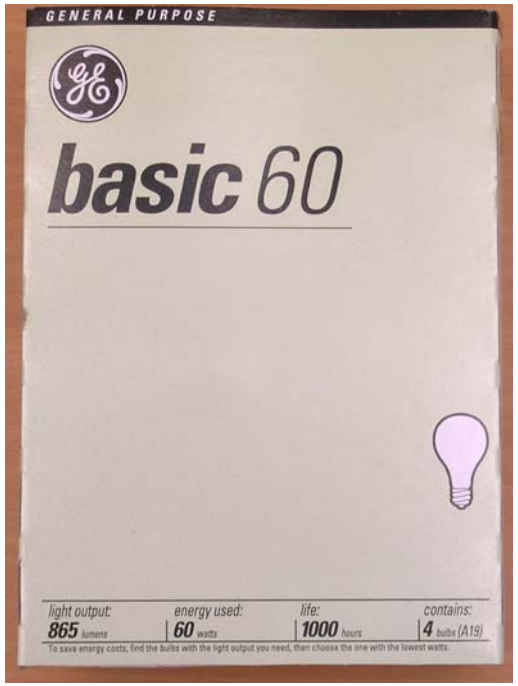
Background on Proposed Tier 2 Efficiency Standards for General Service Incandescent Lamps

Chris Calwell
Ecos Consulting
Presented on behalf of PG&E

July 18, 2005
Sacramento, CA

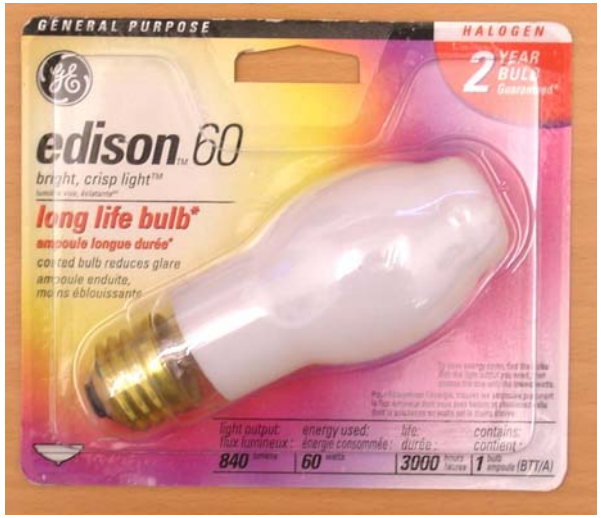

GENERAL PURPOSE
basic 60
light output: 865 lumens
energy used: 60 watts
life: 1000 hours
contains: 4 bulbs (A19)
To save energy costs, find the bulbs with the light output you need, then choose the one with the lowest watts.


GENERAL PURPOSE
soft white 60
regular, everyday light™
QUALITY OF LIGHT SCALE
soft white
regular soft light
reveal®
premium enhanced, vivid light
edison™
exceptional rich, bright light
light output: 840 lumens
energy used: 60 watts
life: 1000 hours
contains: 4 bulbs (A19)
To save energy costs, find the bulbs with the light output you need, then choose the one with the lowest watts.

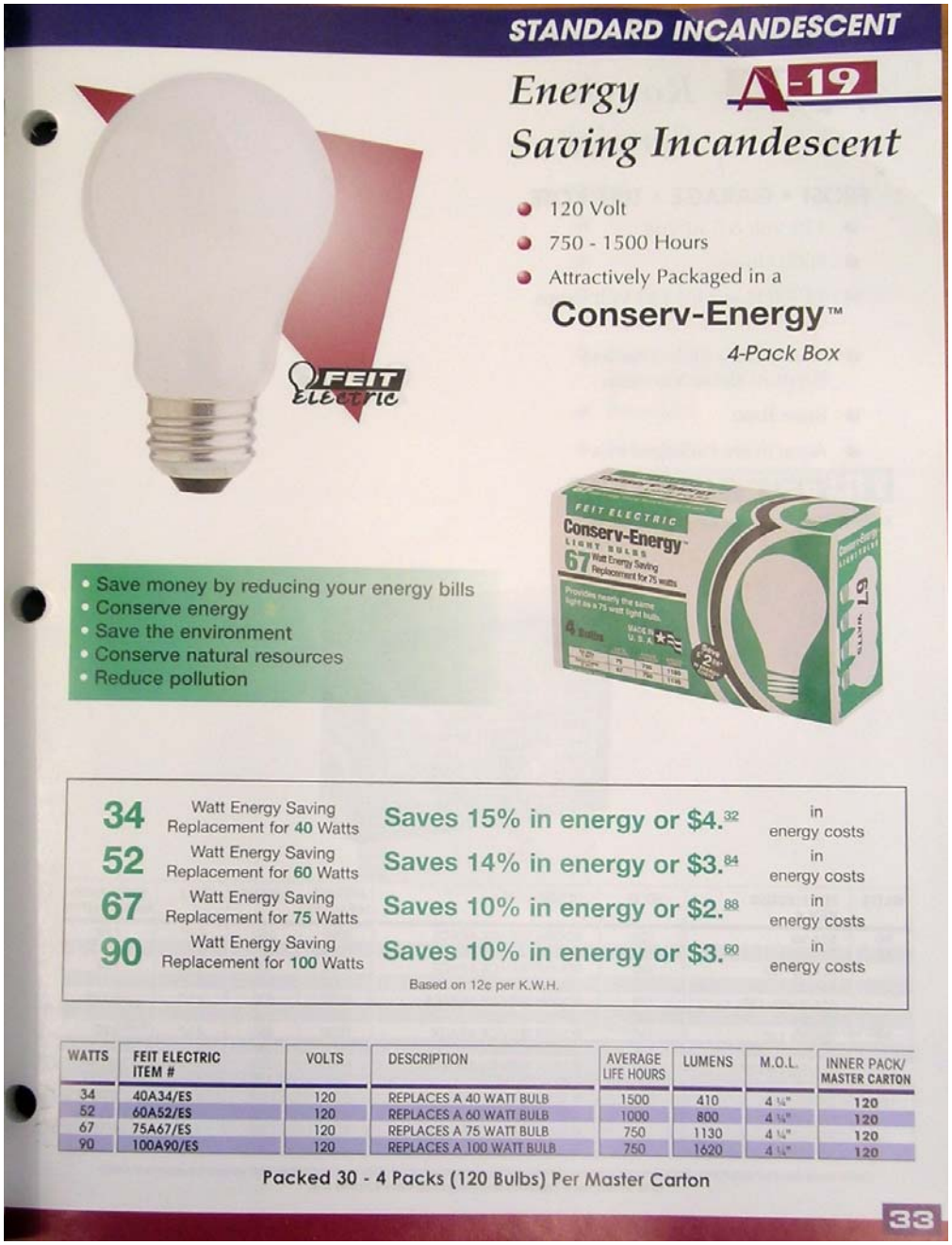

Save $1.60 in Energy Costs*
Lightstyles for Lifestyles™
Soft White Light Bulbs
MISER
Provides Nearly the Same Light as 60 Watt, Avg. Lumens 840, Avg. Life 1000 hours
Light Output 800 LUMENS
Energy Used 55 WATTS
Life 1000 HOURS
Energy Saving Light 55 WATTS
4 Bulbs
To save energy costs, find the bulbs with the light output you need, then choose the one with the lowest watts.
*See Back For Details


Soft White Light Bulbs
2 TIMES LONGER LIFE
than our standard bulb*
Light Output 780 LUMENS
Energy Used 60 WATTS
Life 2000 HOURS
Soft Pleasing Light 60 WATTS
4 Bulbs
To save energy costs, find the bulbs with the light output you need, then choose the one with the lowest watts.


GENERAL PURPOSE
reveal® 60
clean, beautiful light™
ENHANCED COLOR SPECTRUM
light output: 630 lumens
energy used: 60 watts
life: 1000 hours
contains: 4 bulbs (A19)

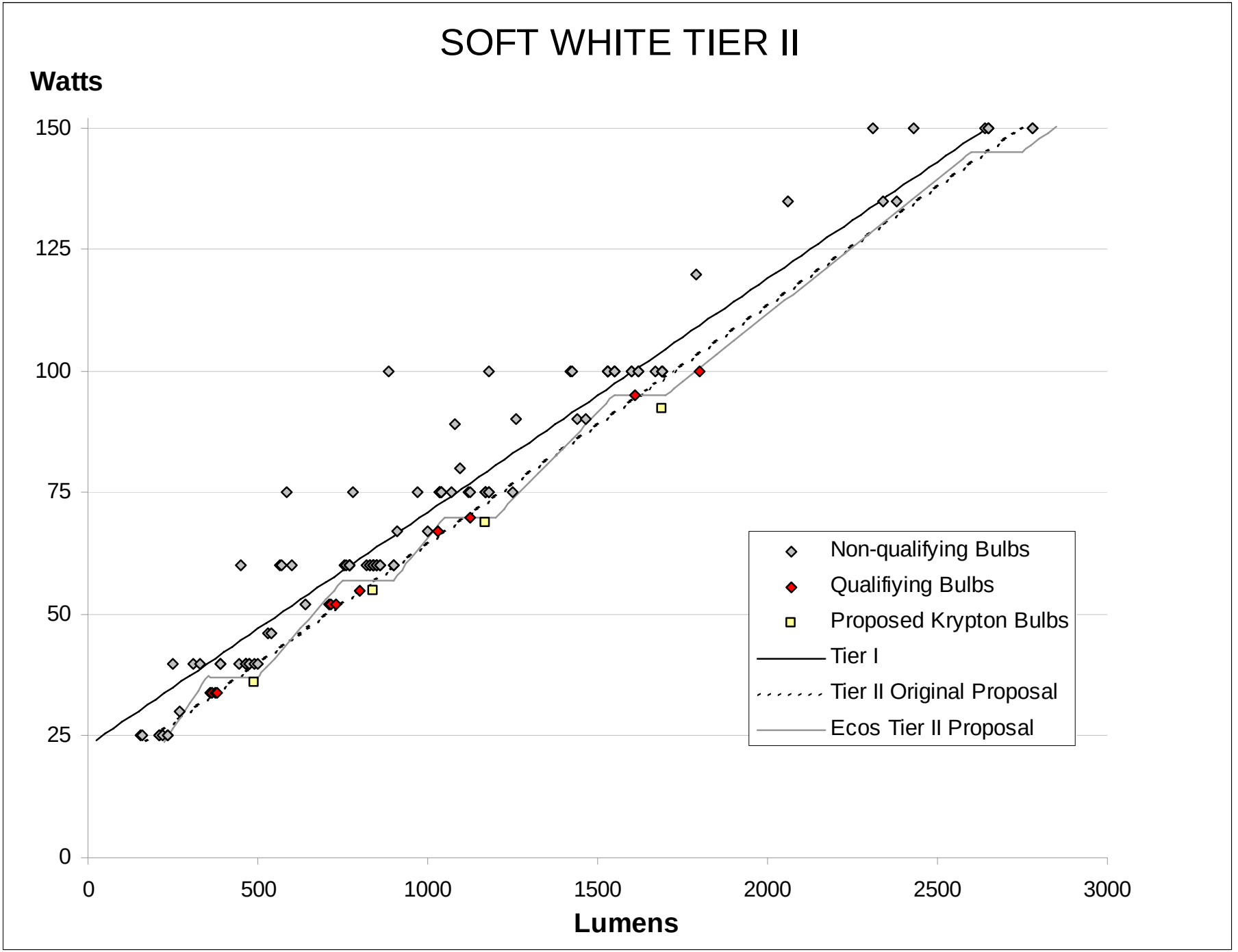

GENERAL PURPOSE
HALOGEN
2 YEAR BULB
edison™ 60
bright, crisp light™
long life bulb*
ampoule longue durée*
coated bulb reduces glare
ampoule enduite, moins éblouissante
light output: 840 lumens
energy used: 60 watts
life: 3000 hours
contains: 1 bulb (BT/A)

Other Approaches to Marketing Efficient Incandescents



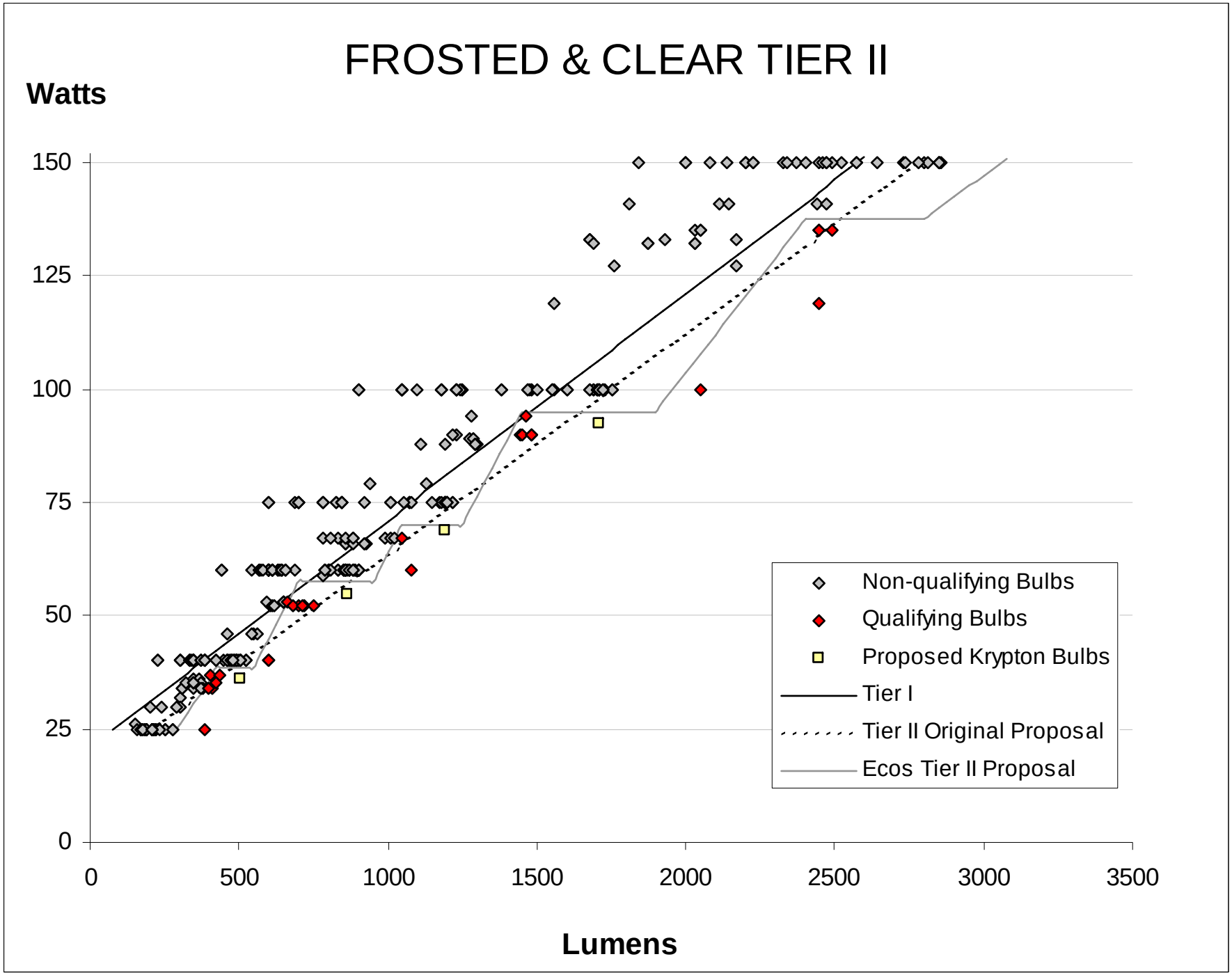
Background

- Tier 1 standards adopted by CEC in December 2004 and take effect in 2006
- Tier 2 standards deferred by CEC pending additional discussion with industry regarding technical approaches and marketing strategies
- Stakeholder meeting held in Davis, CA in January 2005 for additional discussion of krypton lamp analysis and opportunities for California to help market more efficient incandescent lamps to consumers prior to Tier 2 standards taking effect
- Industry concerns about standards leading to brighter lamps of identical wattage instead of wattage reductions encouraged Ecos and PG&E to reformulate their Tier 2 proposal, obtaining all new catalog data and proposing “steps” beneath common wattages


SOFT WHITE TIER II
Watts
150
125
100
75
50
25
0
0
500
1000
1500
2000
2500
3000
Lumens
Non-qualifying Bulbs
Qualifiying Bulbs
Proposed Krypton Bulbs
Tier I
Tier II Original Proposal
Ecos Tier II Proposal

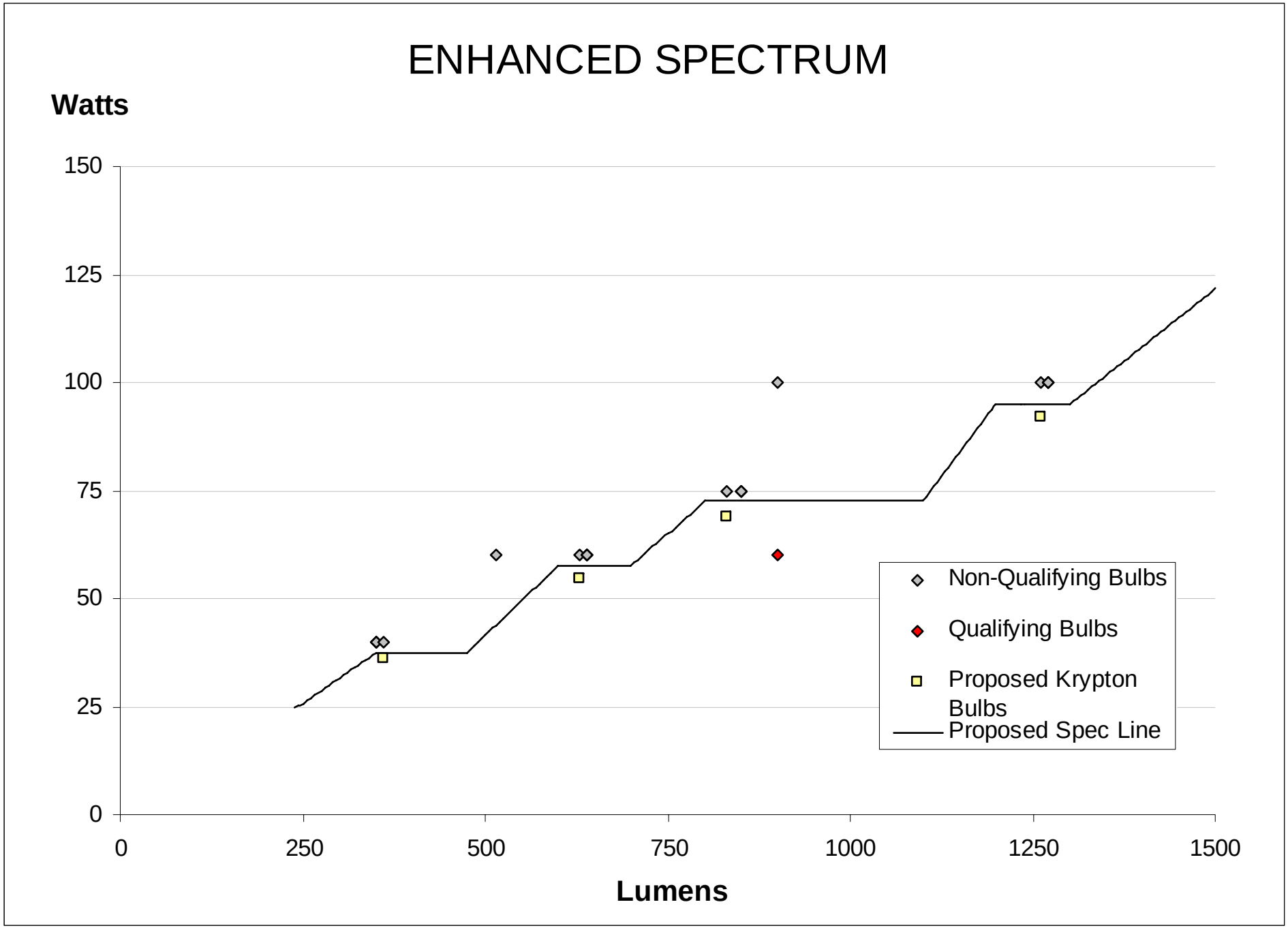
Compliant Soft White Lamps

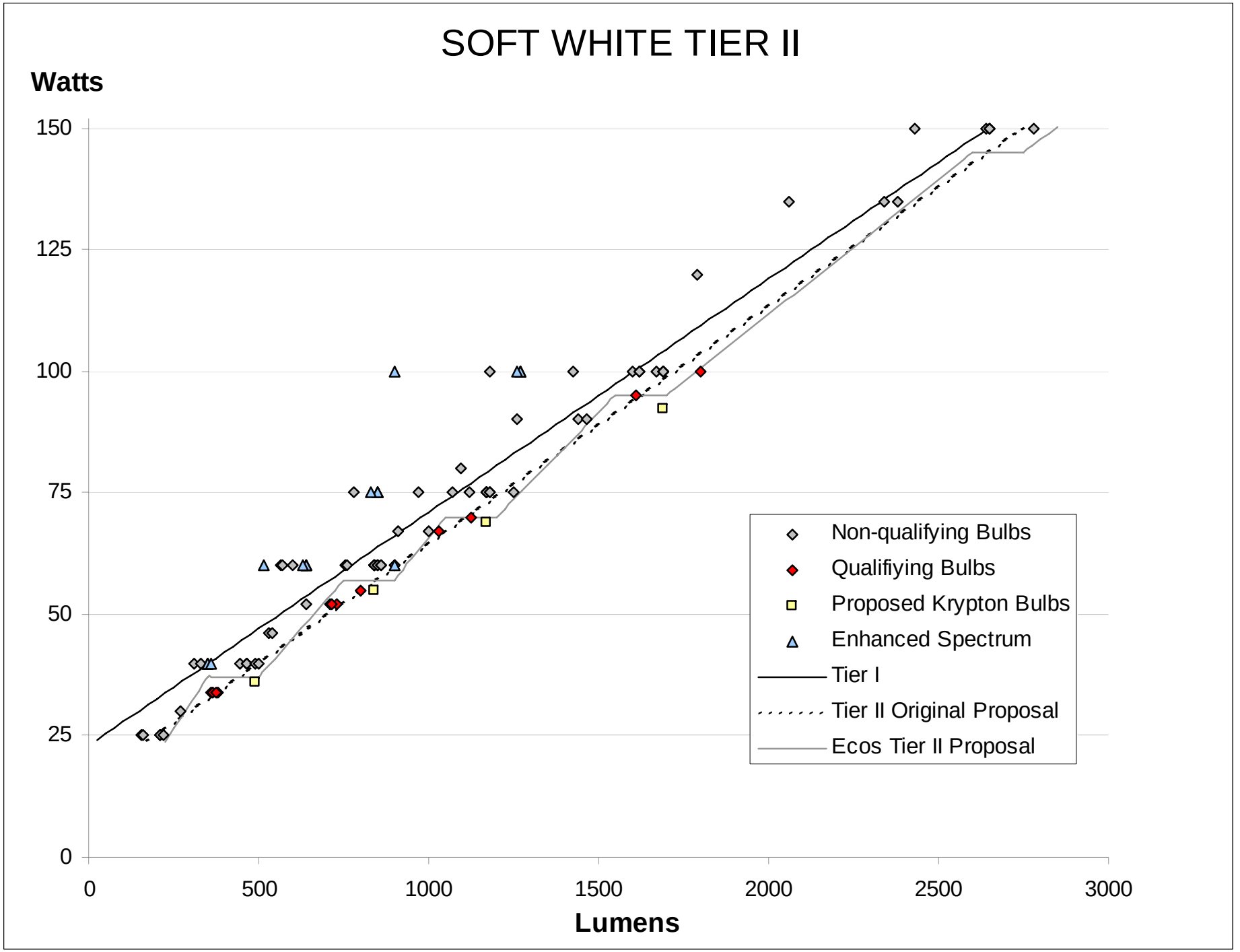
Manufacturer	Description	Bulb Shape	Product #	Ordering Code	Volts	Life (hrs)	Power (watts)	Light output (lumens)
General Electric	Watt-Miser® Plus-Diffuse Coating.	A19	13009	40A/34WMP/99	130	2500	34	360
General Electric	Watt-Miser®-Diffuse Coating	A19	12620	40A/34WM	130	2000	34	365
General Electric	Watt-Miser®-Diffuse Coating	A19	12612	40A/34WM	120	2000	34	380
General Electric	Watt-Miser®-Diffuse Coating	A19	12623	60A/52WM	130	1000	52	710
General Electric	Watt-Miser®-Diffuse Coating	A19	12615	60A/52WM	120	1330	52	730
General Electric	Soft White, Miser®	A19	11904	55A/SW/MI 48PK	120	1000	55	800
General Electric	Watt-Miser®-Diffuse Coating	A19	12617	75A/67WM	120	1000	67	1030
General Electric	Soft White Miser	A19	11905	70A/SW/MI 48PK	120	750	70	1125
General Electric	Soft White Miser	A19	11906	95A/SW/MI 48PK	120	750	95	1610
Sylvania	Soft White Energy Saver	A19	11391	40A/34/W/ES/4PK	120	1500	34	375
Sylvania	Soft White Energy Saver	A19	11392	60A/52/W/ES/4PK	120	1000	52	715
Westinghouse	Soft White	BT15	36822	100BT15/H/SW/CD	120	2000	100	1800


FROSTED & CLEAR TIER II
Watts
150
125
100
75
50
25
0
0
500
1000
1500
2000
2500
3000
3500
Lumens
Non-qualifying Bulbs
Qualifying Bulbs
Proposed Krypton Bulbs
Tier I
Tier II Original Proposal
Ecos Tier II Proposal

Compliant Frost/Clear Lamps

Manufacturer	Description	Bulb Shape	Product #	Ordering Code	Volts	Life (hrs)	Power (watts)	Light output (lumens)
Feit	Frost 24-Pack, 14400 Hours			40A/XL/MP-130	130	5000	40	600
Feit	Clear 24-Pack, 14400 Hours			40A/CL/XL/MP-130	130	1000	40	600
General Electric	Watt-Miser®-Clear	A19	13555	60A/52WM/CL	130	1000	52	720
Philips	Frost Econ-o-Watt	A19	22235-6	40A-34A/EW	130	1500	34	400
Philips	Frost Extended Service	A19	37400-9	40A/99	120	5100	37	405
Philips	Frost Econ-o-Watt	A19	22234-9	40A-34A/EW	120	1500	34	410
Philips	Clear	A19	37399-3	40A/CL	120	2550	37	435
Philips	Clear	A19	37522-0	60A/CL	120	2830	53	665
Philips	Frost Econ-o-Watt Extended Service	A19	22239-8	60A-52A/EW	130	1000	52	680
Philips	Frost Econ-o-Watt	A19	22237-2	60A-52A/EW	120	1000	52	700
Philips	Frost Econ-o-Watt	A19	22243-0	100A-90A/EW	120	750	90	1445
Philips	Frost	A21	28171-7	100A21	120	1280	94	1463
Philips	Frost	A21	34803-7	100A	120	1000	100	2050
Philips	Frost Econ-o-Watt	A21	28175-8	150A-135A/EW	130	750	135	2490
Sylvania	Standard Frost	A19	10449	25A	120	1000	25	385
Sylvania	Clear Excel-Line SS	A19	11053	40A/CL/99/XL	120	2500	35	420
Sylvania	Standard Frost Super Saver	A19	11380	60A/52/SS	130	1000	52	710
Sylvania	Standard Frost Super Saver	A19	11376	60A/52/SS	120	1000	52	750
Sylvania	Standard Frost Super Saver	A19	11377	75A/67/SS	120	750	67	1050
Sylvania	Standard Frost Super Saver	A19	11396	100A/90/W/ES/4PK	120	750	90	1450
Sylvania	Standard Frost Super Saver	A19	11378	100A/90/SS	120	750	90	1480
Sylvania	Standard Frost Super Saver	A19	11382	100A/90/SS	130	750	90	1480
Sylvania	Standard Frost Super Saver	A21	12820	150A21/135/SS	120	750	135	2450
Sylvania	Standard Frost Super Saver	A21	12863	150A21/135/SS	120	750	135	2450
Sylvania	Standard Frost Super Saver	A21	12863	150A21/135/SS	120	750	119	2450
Westinghouse	Clear	BT15	36819	60BT15/H/CD	120	3000	60	1080


ENHANCED SPECTRUM
Watts
150
125
100
75
50
25
0
0
250
500
750
1000
1250
1500
Lumens
Non-Qualifying Bulbs
Qualifying Bulbs
Proposed Krypton Bulbs
Proposed Spec Line


SOFT WHITE TIER II
Watts
150
125
100
75
50
25
0
0
500
1000
1500
2000
2500
3000
Lumens
Non-qualifying Bulbs
Qualifiying Bulbs
Proposed Krypton Bulbs
Enhanced Spectrum
Tier I
Tier II Original Proposal
Ecos Tier II Proposal

Technologies for Improving Incandescent Efficiency

- Coiled-coil filaments
- “Tune” lamps for greater efficiency but shorter life
- Increase coating transparency for lamps used in enclosed fixtures
- Krypton/Xenon fill gas instead of argon
- Dichroic coatings -- Infrared reflective halogen
- More dramatic technologies in development – ceramic filaments, selective emitters, photonic lattices

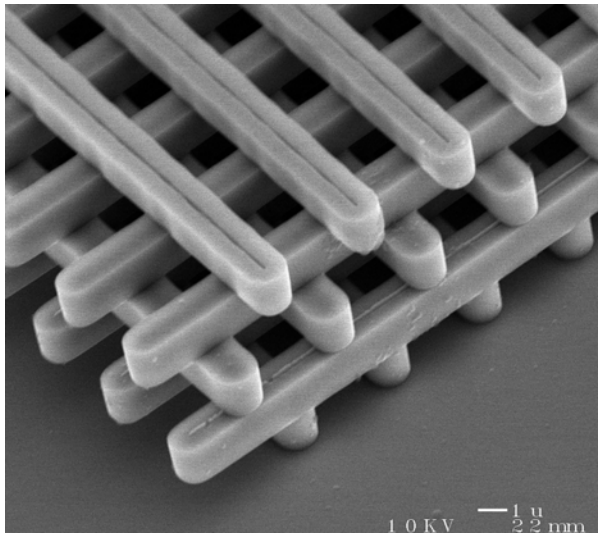
INVENTIONS & INNOVATION
Project Fact Sheet

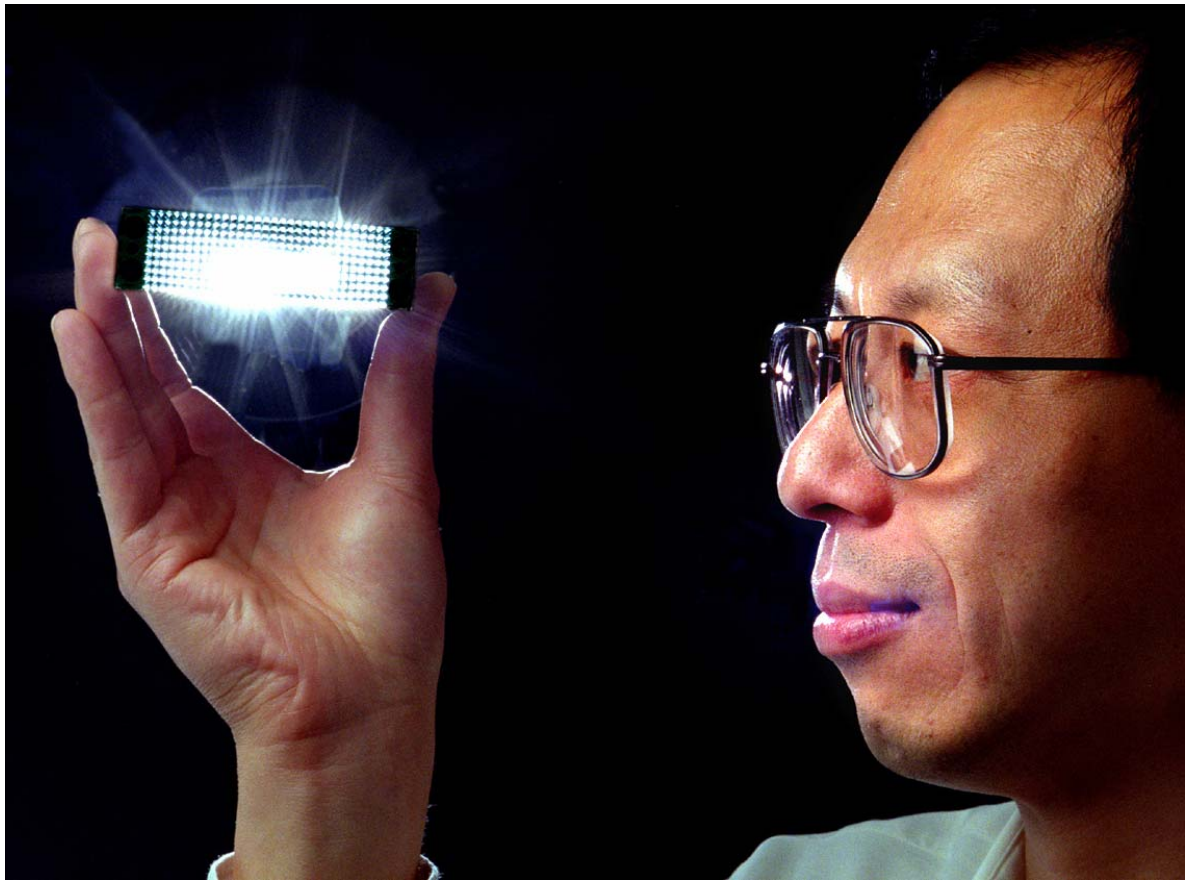
MULTIELEMENT SELECTIVE EMITTER

New Filament Technologies

(Sonsight)

Carbon-based filaments (Ripple Effect International)





Photonic Lattice (Sandia Labs)

Krypton Analysis

- Global production: 50 to 60 million liters/year
- Price: $0.35 to $0.65/liter
- Amount of krypton needed in a standard incandescent lamp (90% Kr, 10% N at 0.8 atm): 75 to 108 cubic centimeters
- Incremental cost of replacing argon with krypton in a typical incandescent lamp: 2.6 to 7.0 cents
- Assumed markup to final customer: 300%
- Incremental retail cost: 7.8 to 21.0 cents

Key Market Data for Krypton

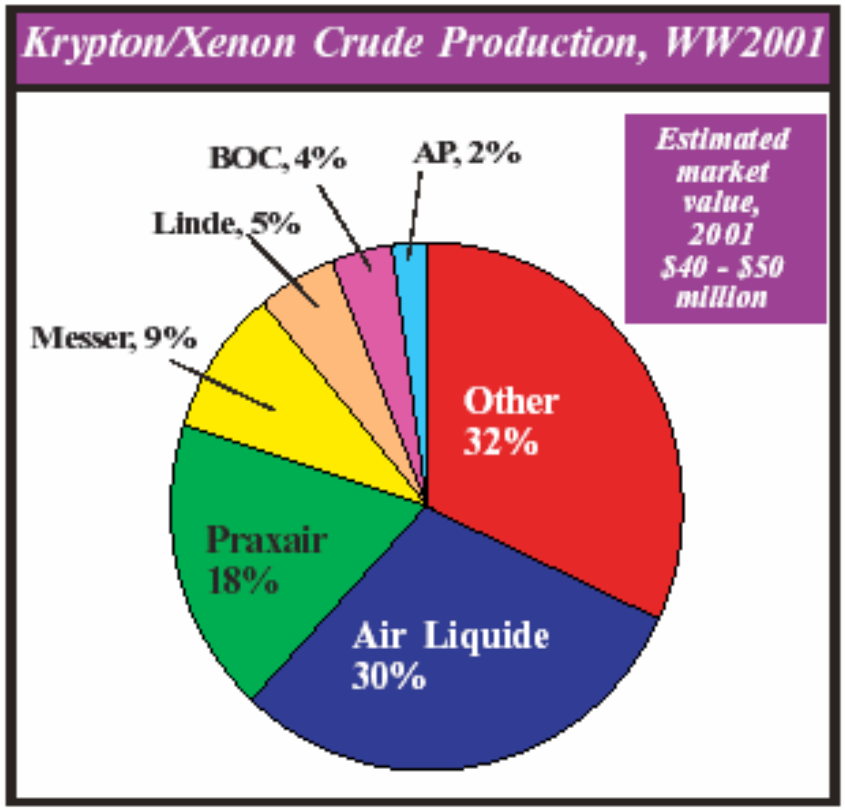


Figure 1 Source: J.R. Campbell & Associates, Inc.

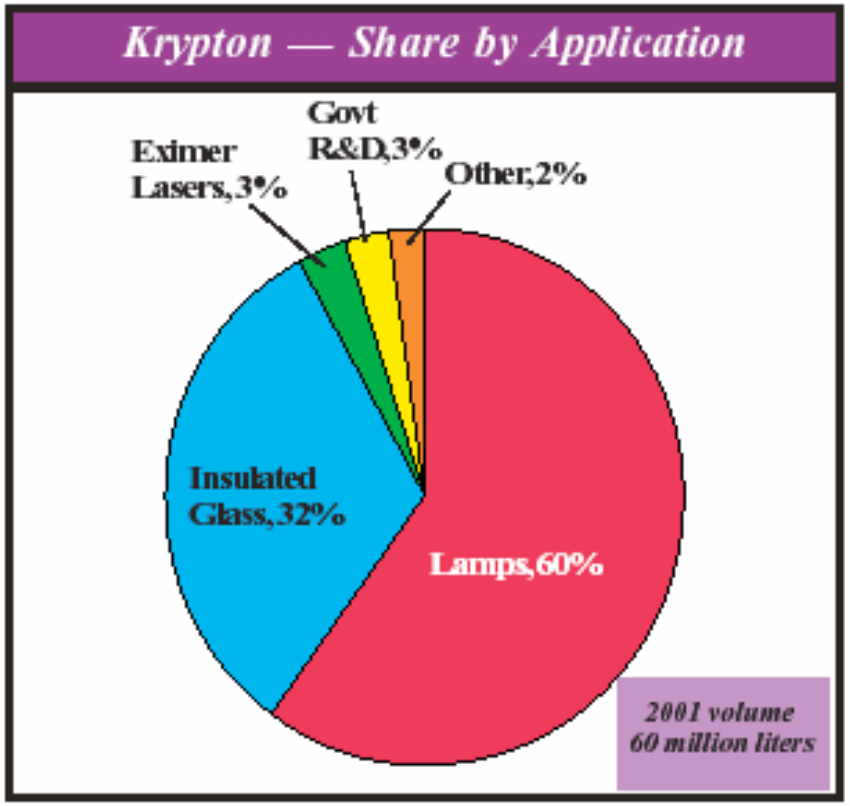


Figure 2 Source: J.R. Campbell & Associates, Inc.

The best way to bright light.

OSRAM SUPERLUX® KRYPTON

SEE THE WORLD IN A NEW LIGHT

OSRAM

Up to 10 % more light

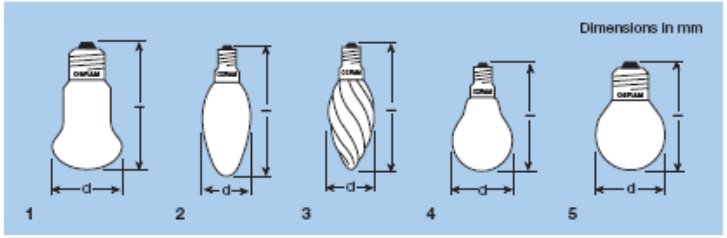
As far as brightness and quality of light are concerned, OSRAM SUPERLUX® KRYPTON lamps are miles ahead of ordinary light bulbs. Thanks to their krypton filling they provide up to 10% more light. Their high-quality coating ensures that the light is uniformly white and glare-free. This modern high-power light is therefore ideal for illuminating large rooms or areas used for reading or working.

For working and reading

Over your desk you need ligh that is more than just bright. The pleasant uniform light from OSRAM SUPERLUX® KRYPTON cuts down on annoying reflections on the work surface, the computer or any other reflective material. Bright light is important if you want to relax with a book without straining your eyes. Many fittings however restrict you to a relatively low wattage. This is where OSRAM SUPERLUX® KRYPTON can help, because it provides considerably more light than an ordinary light bulb from the same wattage.

Look out for the boxes or blister packs. Whichever you choose, the benefits of OSRAM SUPERLUX® KRYPTON are clear.

A little light relaxation. Up to 10% more uniform white glare-free light from OSRAM SUPERLUX KRYPTON®.



Sources for Krypton Savings Estimates

- W.E. Thouret, R. Kaufman, and J.W. Orlando, “Energy and cost saving krypton filled incandescent lamps,” *Journal of IES*, April 1975, pp. 188-197.

  35 watts = 40, 54-55 watts = 60, 90-92 watts = 100, 135-138 watts = 150

- W.E. Thouret, H.A. Anderson, and R. Kaufman, “Krypton Filled Large Incandescent Lamps,” *Illuminating Engineering*, April 1970, pp.231-240.

- *IESNA Lighting Handbook: Reference and Applications,* 9th Edition, 2000, p. 6-9.

  “Krypton, although expensive, is used in some lamps where the increase in cost is justified by the increased efficacy or increased life. Krypton gas has lower heat conductivity than argon. Also, the krypton molecule is larger than that of argon and therefore further retards the evaporation of the filament. Depending on the filament form, bulb size, and mixture of nitrogen and argon, krypton fill can increase efficacy by 7 to 20%.“

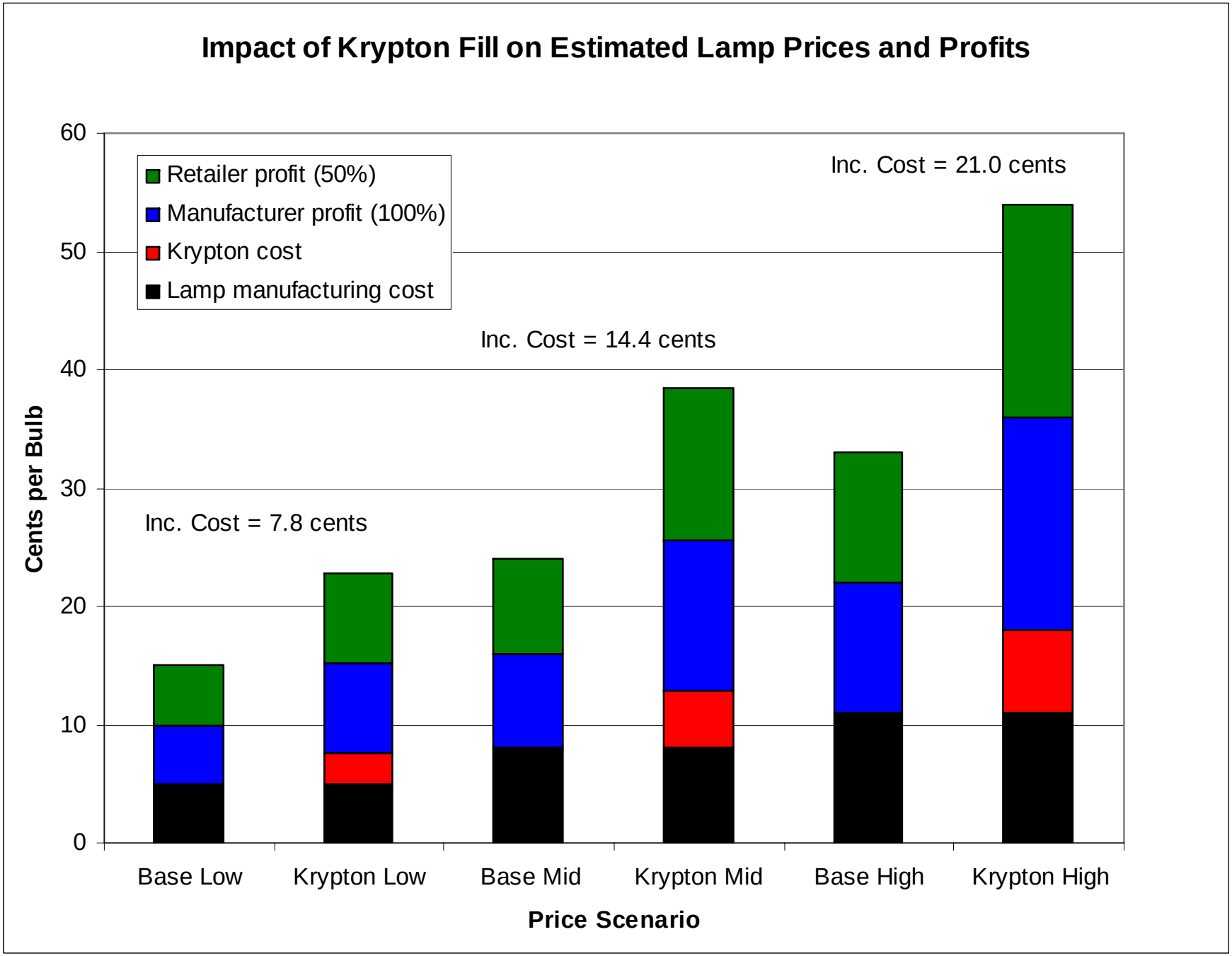
Estimating Savings Per Lamp

- 60 watts (std lamp) – 55 watts (krypton lamp) = 5 watts saved
- Multiply by 1000 hour lifetime
- Average CA residential electricity price according to IEA is 11.5 cents/kwh
- Multiplying by 1,000 for hours cancels with dividing by 1,000 to convert from watt-hours to kwh. Savings can be estimated by simply multiplying watts saved by the electricity price:

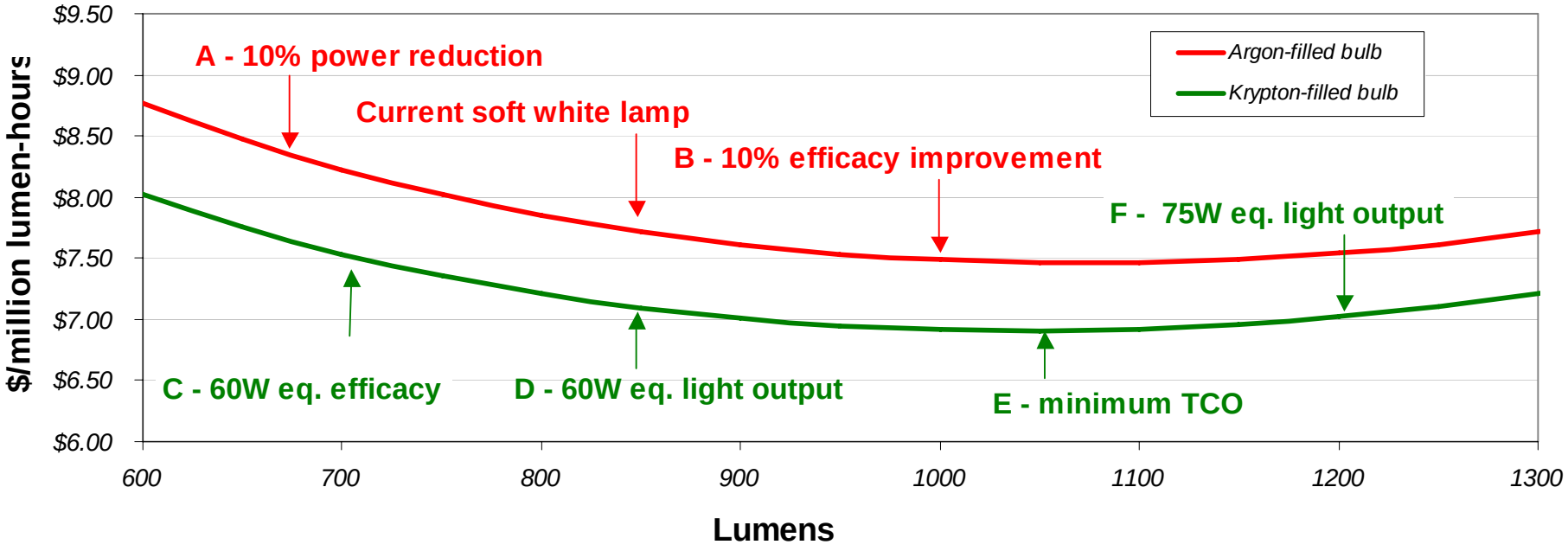
5 * $0.115 = $0.575 for a 60 watt lamp

4 * $0.115 = $0.46 for a 40 watt lamp

8 * 750 * $0.115 / 1,000 = $0.69 for a 100 watt lamp


Impact of Krypton Fill on Estimated Lamp Prices and Profits
Retailer profit (50%)
Manufacturer profit (100%)
Krypton cost
Lamp manufacturing cost
Inc. Cost = 21.0 cents
Inc. Cost = 14.4 cents
Inc. Cost = 7.8 cents
Cents per Bulb
60
50
40
30
20
10
0
Base Low
Krypton Low
Base Mid
Krypton Mid
Base High
Krypton High
Price Scenario

Impact of Krypton Fill Gas and Filament Redesign on Total Cost of Ownership for 60W Incandescent Lamp



Lamp Characteristics	Current	Point A	Point B	Point C	Point D	Point E	Point F
Lumen output:	840	675	1000	700	**840**	1050	**1170**
Power (watts):	60	**54**	65.1	50.2	55.0	60.8	64.1
Efficacy (lumens/watt):	14	12.3	**15.4**	**14**	15.3	17.4	18.5
Life (hours):	1000	2337	513	2008	1000	426	278
TCO/million lumen-hours:	$7.71	$8.35	$7.49	$7.53	$7.09	**$6.91**	$6.99
% TCO savings:	--	-8.3%	2.9%	2.3%	8.0%	10.4%	9.3%

Figure 8. Variation Between Nominal Watts and Average Measured Wattsfor Each Lamp Type

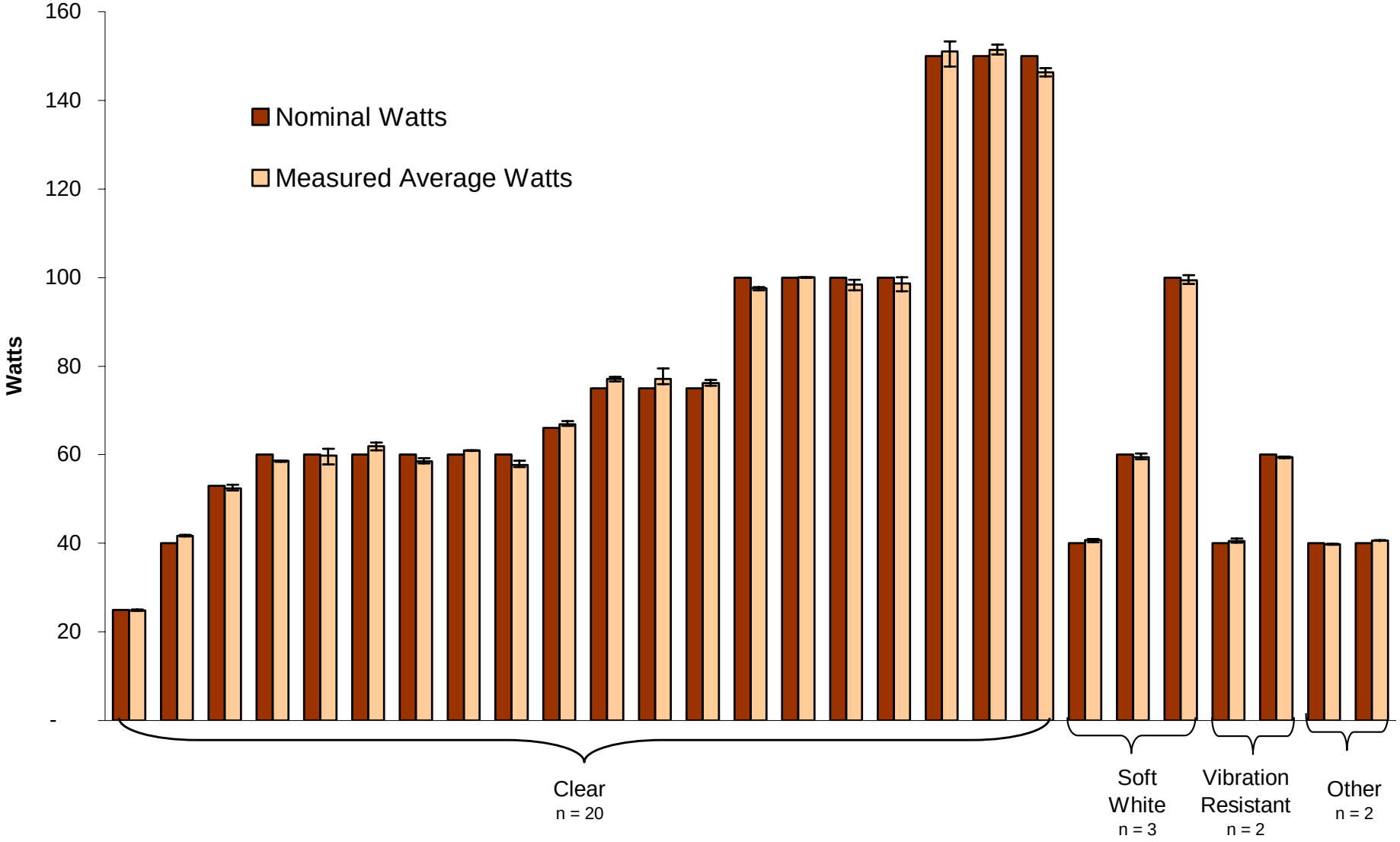
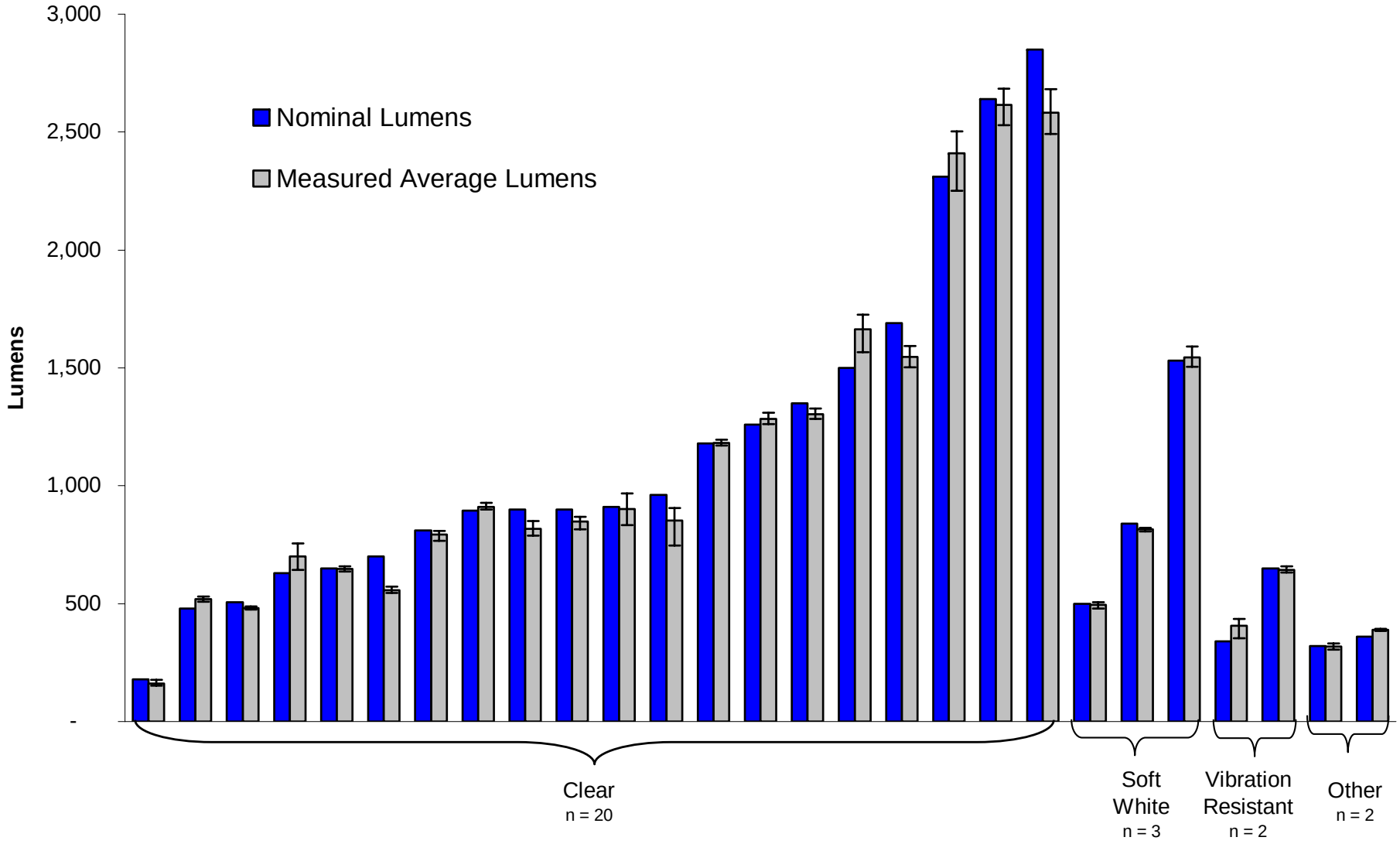


Figure 9. Variation Between Nominal Lumens and Average Measured Lumens for Each Lamp Type



Questions and Comments

- Low voltage lamps – should they be included?
- 130 volt lamps – report lumens and watts at 120 volts, as per FTC requirements in 16 CFR Part 305
- Enhanced spectrum lamp definition
- Test procedure issues
  - Variance from sample to sample – Military Standard 105
  - How many should be tested?
  - Light output (initial lumens) – IES LM 20
  - Lamp life – IES LM 49
- Technology neutrality – can the spec be written to accommodate LED and other technologies?
- Other definition questions?